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A room air temperature model for HVAC simulation

Most dynamics simulation models for buildings operate with a single grid point for the air temperature in the individual rooms. Refinements of the models, such as a high number of capacities in the floor, wall and ceiling elements, give a detailed description of the dynamics of those elements, and it may be reasonable to follow up such improvements with more advanced models for the room temperature distribution.

Vertical temperature gradients in radiator-heated rooms

It is well known that vertical temperature gradients are established in heated rooms, see /1/ and /2/. Thus calculation of the heat flow through ceilings and floors based on a single temperature point in the individual rooms may contain errors in both numerical size and direction, see /3/.

Fig. 1 shows the temperature difference ΔT between ceiling and floor regions in a test room with radiator heating /2/. It is obvious that this temperature difference is a function of the load and it is also a function of the location of the radiator in relation to the window.

The vertical temperature distribution is a rather linear function of the height in static conditions, see /1/, /2/ and /4/. Unsteady conditions may result in a redistribution of the vertical temperature gradients. Fig. 2 shows some experiments in a radiator-heated room where a window is open for a period of 10 minutes. Three measuring points at different heights show the redistribution in the temperature gradients during the cooling period and partly during the heating period /5/.

A model for temperature distribution in radiator-heated rooms

It is reasonable to describe the vertical temperature gradient $\Delta T/\Delta y$ as a function of the load Q and the location of the radiator. Fig. 3 shows $\Delta T/\Delta y$ in steady conditions at different heat loads from different experiments where the radiator is placed below the window. It is obvious that a model of the type $\Delta T/\Delta y$ = const. $\cdot$ Q is a better description than $\Delta T/\Delta y = 0$ as used in the single point description. This could be extended with terms which take into consideration the location of the radiator and other geometrical parameters. Models of the same type may be evaluated for ceiling-heated systems and warm air systems.

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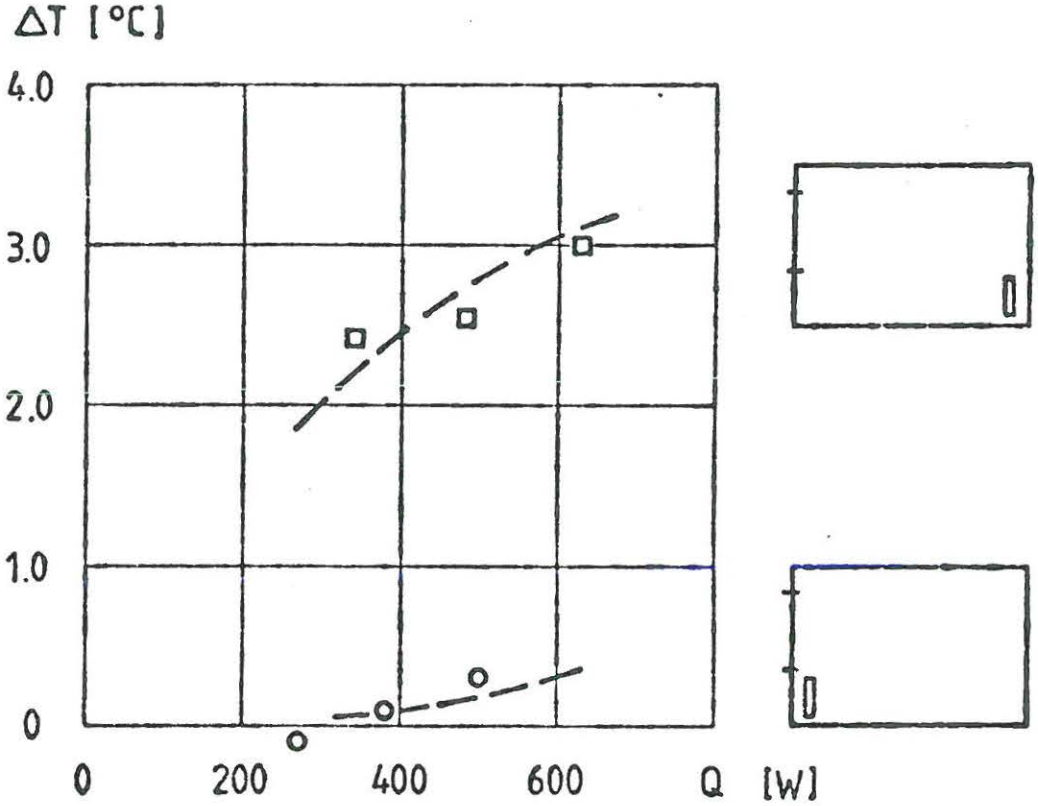

Fig. 1. Temperature difference between the height y = 1.8 m and y = 0.05 m at different loads and locations of radiator. From /2/.

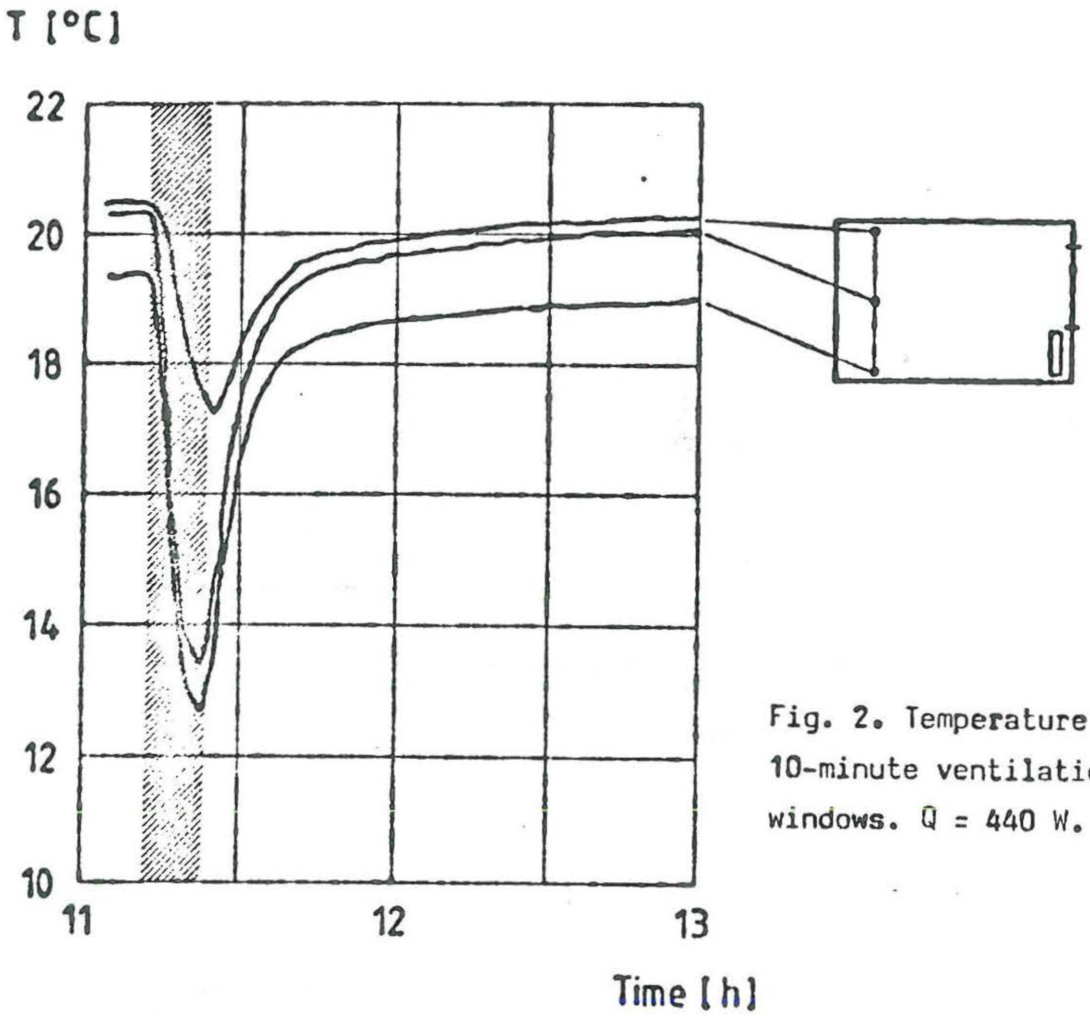

Fig. 2. Temperature distribution during a 10-minute ventilation period from open windows. Q = 440 W. From /5/.

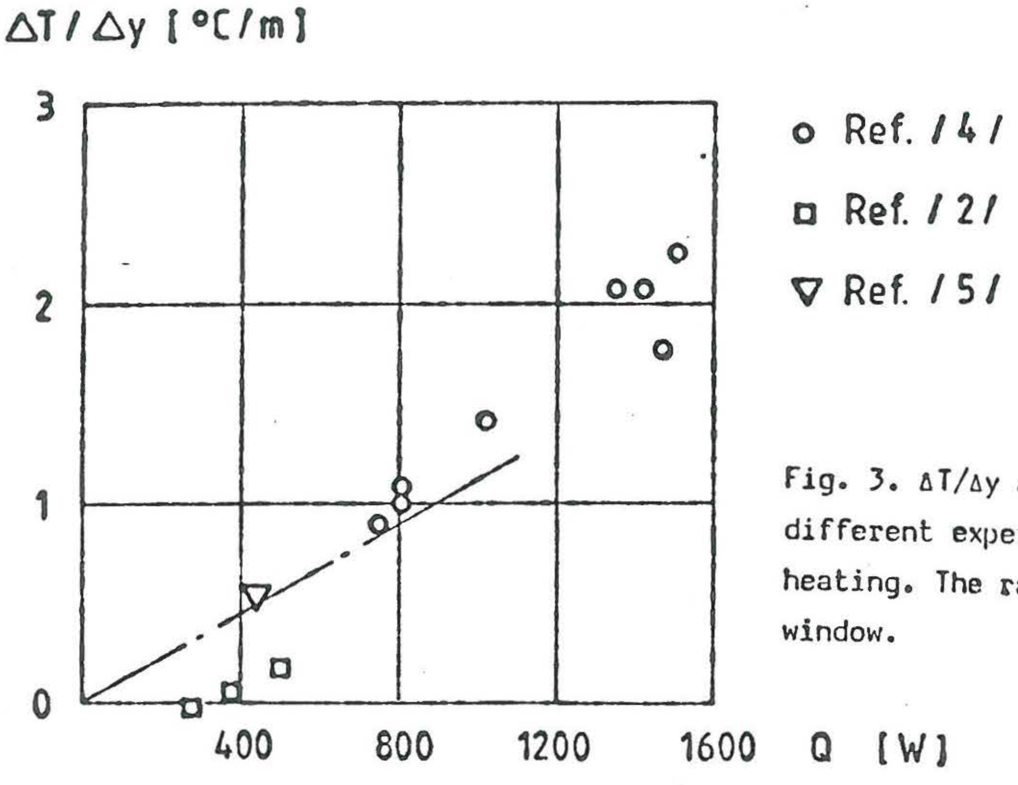

Fig. 3. $\Delta T/\Delta y$ as a function of load from different experiments with radiator heating. The radiator is placed below the window.